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ABSTRACT

This eighth in a series of eight modules for a course titled Metrology describes the overall metrology program and the associated typical responsibilities of the quality assurance/quality control technician. The module follows a typical format that includes the following sections: (1) introduction, (2) module prerequisites, (3) objectives, (4) notes to instructor/student, (5) subject matter, (6) materials needed, (7) procedures, (8) data table, (9) reference materials, (10) test. (The course is one of fifteen technical courses for the second year of a two-year postsecondary curriculum in Nuclear Quality Assurance/Quality Control Technology.) (LRA)

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NUCLEAR TECHNOLOGY

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COURSE 27 METROLOGY

MODULE 27-8 The Total Measurement System

CE 024 260

GENERAL PHYSICS CORPORATION
Columbia , Maryland

INTRODUCTION

Course 31, Quality Assurance Practices, describes eighteen elements of a Quality Assurance Program applicable to a nuclear power plant as required by Title 10, Code of Federal Regulations, Part 50 (10CFR50). Three of the eighteen Quality Assurance Criteria specified by 10CFR50 apply to Metrology. The titles of these three criteria and a condensed statement of each are as follows:

- Criterion X, Inspection - A program of inspections is required to verify conformance of product with specified requirements.
- Criterion XI, Test Control - A program of testing is required to demonstrate that structures, systems, and components will perform satisfactorily in service.
- Criterion XII, Control of Measuring and Test Equipment - Measures are required to control, calibrate and adjust at specified periods measuring and testing devices used in activities affecting quality.

This module describes the overall metrology program and the associated typical responsibilities of the QA/QC Technician. Specifically, QA/QC Technician responsibilities in the following areas are addressed:

1. Inspectability during the design phase.
2. Inspection staging during the manufacturing phase.
3. Inspection planning.
4. Establishment of policies and procedures.
5. Criteria for evaluating any portion of inspection and calibration activities.

MODULE PREREQUISITES

The student/trainee shall have completed all previous modules of this course.

OBJECTIVES

Upon completion of this module, the student/trainee shall be able to:

1. Differentiate between inspection and inspectability and state the role each has in metrology.
2. Define inspection staging and describe its role.
3. List six criteria for inspection staging and describe the application of each.
4. List six elements of inspection planning, state the purpose of each, and describe typical applications of each.
5. State the purpose of inspection policies, inspection procedures and inspection instructions.
6. Apply the concept of S.W.I.P.E. to an inspection or calibration function.

NOTES TO INSTRUCTOR / STUDENT

This module is designed primarily for instruction by classroom lecture. It recommends one laboratory exercise for applying the concept of S.W.I.P.E. The Acronym S.W.I.P.E. was defined by Mary Hoskins, a noted metrologist and

contains the following important factors relevant to dimensional metrology:

S = STANDARD
W = WORKPIECE
I = INSTRUMENT
P = PERSON
E = ENVIRONMENT

Each of the above factors as related to dimensional metrology have been considered in some detail in the previous modules of this couse. In this module it will be noted that advance preparation will be necessary to select procedures for students/trainees to evaluate using the S.W.I.P.E. concept.

INSPECTABILITY

Definitions and Role

Inspection and inspectability are defined as follows:

- Inspection - Inspection is the art of critically examining parts by someone other than the producer of the part and with the aid of suitable standards and measuring devices which confirm or deny to the observer that the particular item under examination is within the specified limits of variability.
- Inspectability - Inspectability is the condition of the part which allows inspection to be performed.

As defined, inspection results in acceptance or rejection of the product. Inspection involves the examination to determine if material or work performed is according to specifications and it verifies whether the material or work conforms to a standard. To provide for unbiased objectivity, inspection is normally performed directly by or under the cognizance of the QA/QC Department, as opposed to manufacturing or maintenance departments. However, inspection defined in this manner is never intended to relieve in any way the responsibility of the manufacturing and maintenance departmens to produce an acceptable product. Instead, the role of inspection is to measure the effectiveness of the product of conforming parts by the manufacturing or maintenance department.

Inspectability applies to both design activities and staging during manufacturing. Its role is to ensure that a given design is capable of being inspected and to stage the inspection activity at a point in manufacturing which provides capability of inspection.

Inspectability During Design

In its broadest sense, inspectability encompasses review of designs to determine if product features can be inspected and also review of measuring devices and practices to determine if adequate equipment and skills are available to perform inspection. In either case, the knowledge and experience of the inspection activity can prevent problems during manufacturing, construction, testing, operations and maintenance phases if good communications exist between engineering and inspection activities. Typical means of communication include the following:

- Scheduled meetings to periodically review concerns and exchange information.
- Unscheduled meetings to review concerns as the need arises.
- Independent design reviews by a task force to determine, among other things, the inspectability of the design.

The Quality Assurance Manager normally has lead responsibility for communicating with engineering. The QA/QC Technician supports the QA Manager by conducting investigations, studies, special reviews, etc., to supply information pertaining to inspectability. Such information is important for review of designs initially and for subsequent feedback to engineering on the results of the manufacturing, construction, and maintenance plans. Such later feedback helps engineering to improve subsequent designs. The evaluation criteria described later in this module should assist the QA/QC Technician in accomplishing this supportive role.

INSPECTION STAGING

Definition and Purpose

Inspection staging is defined as the process of matching the point of inspection with the appropriate manufacturing step. Its purpose is to ensure that inspection is performed at a point where inspectability exists but where any later manufacturing steps will not affect the inspection results.

Types of Inspection Staging

Manufacturing, construction and maintenance activities are accomplished in accordance with pre-established instructions. Such instructions may be a simple listing of processing steps such as, (1) saw, (2) machine, (3) clean and, (4) inspect. Or they may involve detailed instructions on each processing step. The complexity of the work processes and the governing codes and regulations determine the detail contained by manufacturing, construction and maintenance instructions. Regardless of detail, a determination is needed to establish the points of manufacturing, construction, or maintenance where inspection will occur. Such determination is made by engineering or quality assurance/quality control or both. Such determination is made for two types of inspections: in-process and final.

In-process inspection serves to assist the manufacturing, construction, or maintenance activity to produce an acceptable product. It is typically employed with the following activities:

- Layout - Layout involves the establishment of datums or base line information from which initial machining, assembly, or other processing operations can obtain a reference origin. For complex layouts, the inspection activity either performs the layout or checks the layout made by another group.

Layout is actually the opposite of inspection, which was discussed previously. Layout is the preparation of material so that work can be performed according to specifications, whereas inspection was described as the examination to determine whether material or work performed in according to specifications.

Layout typically refers to scribing lines to show limits for milling, grinding, or band machining, and the location of centers or diameters to be drilled, turned or bored. The layout furnishes a guide, but the precision of the machine tool determines the actual dimensions. The layout limits the precision of the machining. A part may be ruined by bad machining regardless of the care used in layout. However, if the layout is in error, the part will not comply to specifications no matter how carefully it was machined.

- Setup - Many machining, welding, and assembly processes involve complex setups which position the part and tooling correctly with respect to layout datums or previously machined datums. The datum is an assumed level surface used as a reference surface for the measurement of reducing levels with respect to that surface. The inspection activity typically inspects the initial setup and rechecks it as each shift change.
- Production - A roving, random inspection activity is frequently employed to spot check manufacturing, construction, or maintenance processes to gain assurance of continued production of acceptable product. Process control charts employing the statistical analysis techniques described by Module 27-7 are sometimes

employed with such in-process inspection. Where final inspection is impossible after completion of processing statistical in-process inspection also serves to verify acceptability in lieu of final inspection.

Final inspection serves to determine acceptability of product. Individual product features may be accepted based on a sampling inspection described by Module 27-7 or based on 100% inspection. Final inspection means inspection for acceptance purposes. It is not necessarily performed after all processes have been completed. In many cases, final inspection must be staged at discrete points of manufacture, construction, or maintenance in order to satisfy the predominant inspection staging criteria.

Criteria for Inspection Staging

As implifed by its name, in-process inspection requires planning for the stages of manufacture, construction, or maintenance at which the inspection will occur. Similar planning is needed for final inspection. Criteria governing such planning are listed in Table 27-8-1.

Referring to Table 27-8-1, criterion #1 is the basis for employing layout inspection. Such inspection can reduce the rework and repair costs by ensuring correct establishment of initial reference datums. Criterion #2 is the basis for both setup and roving inspection in-process. Again, its purpose is to reduce rework and repair costs. Criterion #3 is a basis for both in-process and final inspection. Since the datum will be referenced in the manufacture of other features, its accurate generation is important to both reduce rework and repair costs as well as for product acceptance. Criteria #4 and #5 are the basis for performing final inspection at an in-process point of manufacture, construction, or maintenance. These criteria demand inspectability

Table 27-8-1

CRITERIA FOR INSPECTION STAGING

Criterion	Applicable To	
	In-Process	Final
1. Establishment of a datum to support initial machining. Such datums result from layout and may be center points, center lines, reference indexing points or lines, true position layout points or lines, reference notches or grooves.)	X	
2. Establishment of a final feature which can be inspected after all processing is completed but which has a relatively high associated risk of nonconformance. (Examples include those critical features upon which function and fit are predicated and which involve difficult or complex manufacturing, construction, or maintenance steps. Discovery of a number of nonconforming parts with such features probably means a large rework or repair cost. Size, form, and position of mating surfaces, holes, threads, pins, nozzles, seals, supports, bearings and mounts are candidates for such critical features.)	X	
3. Establishment of a datum feature referenced by subsequent manufacturing, construction, or maintenance steps. (Such datum features may be surfaces or axes.)	X	X
4. Establishment of a final feature from a datum where such datum will be removed or modified by subsequent processing. (Such cases normally involve the need for a datum from which to index the machine where the final part does not require such a datum.)		X
5. Establishment of a final feature which will be made inaccessible by later processing. (Examples include size, location or form limits which are applicable prior to plating, painting welding or assembly.)		X
6. Features accepted by final inspection must not be altered by subsequent manufacturing, construction, or maintenance.		X

for final inspection. For either criterion, subsequent processing makes final inspection impossible. Criterion #6 prohibits premature application of final inspection by criteria #4 and #5.

INSPECTION PLANNING

Purpose

Inspection planning means the establishment of a predetermined scheme for inspection of product. Each company plans its inspection activity based on its liability. For example, a nuclear utility, who purchases components for installation by the construction contractor, develops inspection plans focused on those few significant product features which involve function of the component and interfacing with other components. The manufacturer of the component develops inspection plans for the many features which must be correct to permit assembly, function, and installation. Regardless of the focus of such planning, inspection planning has the purpose of ensuring the accomplishment of inspection of important product features at the correct point of manufacture, construction, or maintenance.

Elements of Inspection Planning

Inspection planning results in instructions for the inspection activity. The detail of such instructions varies among companies dependent on the management policies, the complexities of the inspections, the qualifications of the inspectors, and the requirements of codes, standards, and regulations. Nonetheless, inspection planning must generally encompass designation of features, establishment of notification selection of instruments, special instructions, acceptance criteria, and records. The QA/QC Technician

may perform inspection planning or may assist a quality engineer in inspection planning.

- Designation of Features - This portion of inspection planning designates what will be inspected. The specific features selected is a function of the purposes of the inspection. The planner reviews engineering drawings and components or system codes and specifications and selects those product features important to fit, function, and interchangeability. Such features are normally documented by the planner as an inspection check list which is issued to the inspectors. A sample inspection check list is given in Appendix A.
- Establishment of Notification - This portion of inspection planning ensures that the inspection force is afforded the opportunity to inspect the designated features. It coordinates the manufacturing, construction, or maintenance activity with the inspection activity. Notification must encompass both in-process and final inspection and coincide with the staging of such inspection. Notification may be established in basically two ways. Either the processing is arranged such that the product must physically move to inspection stations at appropriate times or processing paper work accompanying the product requires oral notification to inspectors at designated processing steps. Except for some manufacturing activities, the latter approach is generally used. For the latter approach, the planner reviews the processing instructions governing the manufacturing, construction, or maintenance and marks those processing steps at which inspectors are to be notified. When the planner knows that inspection must absolutely be performed at some point, that point is marked as "hold for in-

spection". At hold points, processing stops until the corresponding inspection is performed.

- Selection of Instruments - When specific measuring instruments are necessary to inspect the designated features, the planner identifies such instruments normally on the inspection check list. When the level of inspector qualification represents skill and experience sufficient for proper selection of a measuring instrument, the planner need not specify the inspection instrument. The line of demarcation in the planner's practice is normally associated with whether special purpose instruments are demanded by the type of feature and its tolerance. For example, a special gage, consisting of fixturing and dial indicators and made for measuring runout of a certain rotor, would be referenced by the inspection check list for that rotor. The planner also determines if devices are on hand which are capable of inspecting designated features. If not, they are ordered. If suitable instruments are not on the market, the planner consults with the designer and either the design is changed or a special purpose gage is designed and built to perform the inspection.
- Special Instructions - This portion of the planning determines if special conditions apply to inspection of any of the designated features. Such special conditions may be, (1) use of sampling plans, (2) temperature and/or humidity controls, (3) specific inspection techniques, or (4) specific actions such as notifications and records not covered by other applicable procedures.

- Acceptance Criteria - This portion of the planning either identifies the document(s) which gives acceptance criteria or spells out the specific acceptance criteria. Identification of documents which give acceptance critieria has the advantage of not requiring a change to the inspection planning documentation when changes occur to the documents containing acceptance criteria. However, it has the disadvantage of requiring controlled distribution of acceptance documents to the inspection activity. Since drawings give or reference all acceptance criteria for dimensional inspection, the inspection check list normally references the drawing rather than listing tolerances for the designated features. The drawing control system described by Course 31 is relied upon to place the correct drawing at the point of inspection.
- Records - This portion of inspection planning determines the type and nature of records to be completed by the inspection function. As described in Course 31, Quality Assurance Practices, final inspection records must be retained to preserve information on the as-built condition of structures, systems, and components. The planner must decide if the record entry will be a simple indication of acceptability (such as a check mark and the inspector's signature) or the actual measured value. Governing codes, specifications, and regulations are reviewed to make this determination. The record format may take any of the following forms:
  - Entries on the corresponding processing instructions employed by manufacturing, construction, or maintenance.
  - Entries on the inspection check list.

- Entries on a special form designed specifically for recording inspection results.
- Entires on a drawing or layout document used as an inspection record.

INSPECTION POLICIES AND PROCEDURES

Summary Review

The science of measurement, i.e., metrology, as applied to dimensions, is employed to ensure that size, form and position of product features comply with design requirements. It embraces design, manufacturing, construction, maintenance, inspection, and calibration.

- Design activities are concerned with clearly specifying and tolerancing intended sizes, forms and positions and ensuring inspectability of such features.
- Manufacturing, construction and maintenance are concerned with producing, installing, and repair product in conformance with design requirements.
- Inspection concerned with confirming the acceptability of features important to fit, function, and interchangeability.
- Calibration provides traceable measuring instruments of known accuracy for use by manufacturing, construction, maintenance and inspection activities.

The ingredient which gels these concerns into a working system are the management policies and procedures which define responsibilities establish the methods of implementing the principles with metrology.

Inspection Policy

The purpose of a written inspection policy is to advise all department heads within a company of the inspection concepts adopted by senior management of the company. Inspection policy is normally documented as a portion of the company's Quality Assurance Manual. A typical statement of inspection policy is given in Appendix B.

Inspection Procedures

Inspection Procedures implement inspection policy. These procedures typically assign responsibilities to appropriate managers and delineate the extent of inspection planning to be performed. Such procedures also establish responsibilities and practices for the calibration program (see Module 27-6). The QA/QC Technician may be responsible for assisting in the preparation of inspection procedures. A typical inspection procedures on inspection planning is given in Appendix C.

Inspection Instructions

Inspection instructions provide detailed instructions on specific functions required by inspection procedures. Such instructions are employed for those functions so important or so complex as to require written instructions for their satisfactory accomplishment. The QA/QC Technician may be responsible for preparation and maintenance of inspection instructions. Typically, written instructions are comprised of:

- inspection check lists
- records formats and corresponding instructions for their completion
- calibration procedures

EVALUATION OF INSPECTION AND CALIBRATION ACTIVITIES

The QA/QC Technician can be involved with any of the facets of dimensional metrology described by this course. In each area of involvement, the typical job tasks require evaluation of a number of factors to determine the best inspection or calibration practice or to locate error sources in measurements or calibrations. The various modules of this course have collectively presented the principles, elements and capabilities of the metrology program. Such information should serve as a good foundation for performing QA/QC Technician's tasks related to dimensional metrology. Regardless of the specification task, factors presented below serve as a helpful check list in evaluating any facet of the metrology program.

Mary Hoskins, a noted metrologist, has published a paper entitled "Taking a S.W.I.P.E. at Metrology". This paper presents pertinent factors to consider in any evaluation of procedures and practices within the metrology program. The acronym S.W.I.P.E. is defined and its factors are given below:

The acronym S.W.I.P.E. stands for:

S = STANDARD
W = WORKPIECE
I = INSTRUMENT
P = PERSON
E = ENVIRONMENT

- Factors affecting the <u>STANDARD</u>:
  a. Traceability
  b. Geometric Compatability
  c. Coefficient of Thermal Expansion

d. Calibration Interval
e. Stability
f. Elastic Properties
g. Position of Use -- Airy Points

- Factors affecting the WORKPIECE:
  a. Geometric Truth -- Hidden Geometry
  b. Related Characteristics, such as Surface Finish Waviness, Scratch Depth
  c. Elastic Properties
  d. Cleanliness
  e. Surface Defects
  f. Thermal Equalization
  g. Mass Affecting Elastic Deformation
  h. Truth of Supporting Features
  i. Clear Definition of Characteristic to be Measured
  j. Adequate Datums on the Workpiece
- Factors affecting the INSTRUMENT:
  a. Adequate Amplification for Accuracy Objective
  b. Amplification Checked Under Conditions of Use
  c. Effects of Friction, Backlash, Hysteresis, or Drift
  d. Electric, Optical, or Pneumatic Input to Amplifying System Functioning Within Prescribed Limits
  e. Contact Geometry Correct for both Workpiece and Standard
  f. Contact Pressure Control Functioning Within Prescribed Limits
  g. Contacts in Correct Geometrical Relationship and Inspected for Wear or Chipping
  h. Slides, Ways, or Moving Elements Not Adversely Affected by Wear or Damage

i. Deformation Effects in the Instrument When Heavy Workpieces are Measured

j. Auxiliary Elements (such as Wires, Rolls, Angles, Plates) Calibrated and Checked for Function

k. Magnification of Errors by Contract Geometry

l. Repeatability and Readability Adequate for Accuracy Objective

- Factors affecting the PERSON:

a. Training

b. Skill

c. Sense of Precision Appreciation

d. Complacent or Opinionated Attitudes Towards Personnal Accuracy Achievements

e. Open-Minded Competent Attitudes Towards Personal Accuracy Achievements

f. Planning Measurements Techniques for Minimum Cost, Consistent With Precision Requirements

g. Appreciation of Scope of Accuracy Evaluation

h. Ability to Select High-Quality Measuring Instruments and Standards With Required Geometrical and Precision Capabilities

i. Sensible Appreciation of Measurement Costs

- Factors affecting the ENVIRONMENT:

a. Standard Length-Measuring Temperature is $68^{\circ}F$; ($20^{\circ}C.$); for Electrical Measurements, it is $25^{\circ}C$ or $28^{\circ}C$. For pressure measurements it is $23^{\circ}C$.

b. Temperature Equalization Between Standard, Workpiece, and Instrument; Deficiency of One Degree in Equalization Could Introduce in Steel an Error of 6.5 Millionths Inch per Inch of Length

c. Thermal Expansion Effects Due to Heat Radiation From Lights, Heating Components, Sunlight, and People

d. Effects of Cycles in Temperature Control
e. Impinging Drafts of Air Which May Introduce Thermal Expansion Size Errors
f. Manual Handling May Introduce Thermal Expansion Errors; Human Body Temperature is 30°F Higher Than Standard Measuring Temperature; For One-Inch Length of Steel, This Could Cause Error up to 0.0002 Inch
g. Clean Surroundings and Minimum Vibration Enhance Precision
h. Adequate Lighting
i. Atmospheric Refraction Effects in Optical Measuring Systems (air density, humidity, pressure, temperature).
j. Thermal Gradients, Either Vertical or Lateral, in the Measuring Area

EXERCISES

. Discuss the meaning of the terms inspection and inspectability regarding the examination of parts for the purpose of acceptance.
2. Explain how QA/QC communication with design activities of a project serves to ensure inspectability.
3. Explain the process of inspection staging and identify how maximum benefit is obtained in the form of lower rework and repair costs.
4. Discuss what is meant by process inspection.

5. List and briefly discuss the six criteria which govern the decisions on inspection staging as discussed in this module.
6. Inspection planning ensures the accomplishment of staged inspections and it consists of:
   a. designation and features
   b. establishment of notifications
   c. selection of instruments
   d. special instructions
   e. acceptance criteria
   f. records

   Briefly explain each of the components of inspection planning.
7. The concepts of S.W.I.P.E. offers a check list for evaluating metrology tasks to ensure consideration of factors effecting accuracy and precision of measurements and calibration. Briefly explain each of the components identified by this acronym.
8. Apply the concept of S.W.I.P.E. to an inspection or calibration procedure as identified in the Procedures Section of this module.

MATERIALS

Obtain an inspection or calibration procedure which can be used to carry out an exercise to apply concept of S.W.I.P.E. as discussed in this module.

PROCEDURES

Given an inspection or calibration procedure, evaluate the effectiveness of the procedure in terms of how well it ensures accuracy and precision. The evaluation should check each factor listed under S.W.I.P.E. The evaluation should result in a report which identifies recommended changes to the procedure for improving its effectiveness. The basis for each recommended change should be given.

DATA TABLE

Not Applicable.

REFERENCE MATERIALS

Farago, Francis T., PhD, Handbook of Dimensional Measurement, Industrial Press Incorporated, Third Printing, 1968.

Hoskins, Mary E., "Taking a S.W.I.P.E. at Metrology", Presented at Merging Metrology Conference, Hartford, Connecticut, November, 1968.

Juran, J.M., Quality Control Handbook, McGraw-Hill Book Company, New York, New York, Third Edition, 1974.

Society of Manufacturing Engineers (SME), Handbook of Industrial Metrology, Prentice-Hall, Incorporated, 1967.

TEST

Read each question carefully, Be sure to provide the specific information each questions requires. Make your answers brief as possible.

1. Differentiate the concepts of inspection and inspectability.

2. Describe the role of inspectability.

3. Define inspection staging.

4. Describe the role of inspection staging.

5. Name six criteria of inspection staging and for each state if it applies to inprocess or final inspection.

a.

b.

c.

d.

e.

f.

6. What is the purpose of inprocess inspection?

7. Name six elements of inspection planning and state the purpose of each.

Element	Purpose
a.	
b.	
c.	
d.	
e.	
f.	

8. What is the purpose of Inspection Policy?

_____

_____

_____

_____

9. What is the purpose of Inspection Procedures?

_____

_____

_____

_____

10. What is the purpose of Inspection Instructions?

_____

_____

_____

_____

11. Complete this statement. The acronym S.W.I.P.E. stands for?

S =

W =

P =

I =

E =

12. Describe how the factors of S.W.I.P.E. are used to the QA/QC Technician.

APPENDIX A

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INSPECTION CHECK LIST

Item: HPS Hangers Project: Unit #1

Drawing: 46 HPS G02103 Part No.: 201.8

Acceptance Criteria: Per drawing and purchase order 619

Prepared By: I. M. Perfect (Inspection Planner) Approved By: U. R. Right (Project Engineer)

Characteristics To Be Inspected	Drawing Zone	Special Instructions
Material Certification	Note 3	1. All inspections are to be performed at receiving
Item Identification and Marking	Note 6	2. Use gage H-101 for functional check of 5.985 radius
Cleanliness	Note 8	3. Record results on Form QCI-1 per QCP 16.2
0.385 ± Diameters (4)	D-8, E-8	
True Position 0.385 Diameter (2 Places)	D-8, E-8	
Perpendicularity 0.385 Diameter (4 Places)	D-8, E-8	
5.985 Radius (Functional Check)	D-4	

APPENDIX B

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QAP Ref.

5.10.0 INSPECTION

5.10.1 CRITERION X OF 10CFR50 APPENDIX B STATES:

"A PROGRAM FOR INSPECTION OF ACTIVITIES AFFECTING QUALITY SHALL BE ESTABLISHED AND EXECUTED BY OR FOR THE ORGANIZATION PERFORMING THE ACTIVITY TO VERIFY CONFORMANCE WITH THE DOCUMENTED INSTRUCTIONS, PROCEDURES, AND DRAWINGS FOR ACCOMPLISHING THE ACTIVITY. SUCH INSPECTION SHALL BE PERFORMED BY INDIVIDUALS OTHER THAN THOSE WHO PERFORMED THE ACTIVITY BEING INSPECTED. EXAMINATIONS, MEASUREMENTS, OR TESTS OF MATERIAL OR PRODUCTS PROCESSED SHALL BE PERFORMED FOR EACH WORK OPERATION WHERE NECESSARY TO ASSURE QUALITY. IF INSPECTION OF PROCESSED MATERIAL OR PRODUCTS IS IMPOSSIBLE OR DISADVANTAGEOUS, INDIRECT CONTROL BY MONITORING PROCESSING METHODS, EQUIPMENT, AND PERSONNEL SHALL BE PROVIDED. BOTH INSPECTION AND PROCESS MONITORING SHALL BE PROVIDED WHEN CONTROL IS INADEQUATE WITHOUT BOTH. IF MANDATORY INSPECTION HOLD POINTS, WHICH REQUIRE WITNESSING OR INSPECTING BY THE APPLICANT'S DESIGNATED REPRESENTATIVE AND BEYOND WHICH WORK SHALL NOT PROCEED WITHOUT THE CONSENT OF ITS DESIGNATED REPRESENTATIVE ARE REQUIRED, THE SPECIFIC HOLD POINTS SHALL BE INDICATED IN APPROPRIATE DOCUMENTS."

5.10.2 Nuclear Quality Assurance Program assures quality through inspections, checks, reviews, surveillance and audits of its agents' and suppliers'/contractors' isnpections. Requirements for inspections that are performed during the design and construction phase are an inherent part of specifications established by supplier/contractor requirements. Agents and suppliers/contractors are required to establish and implement approved written inspection programs to verify conformance with requirements in procurement documents. These programs must be consistent with Nuclear Quality Assurance Program-Design and Construction and approved by the Manager, Quality Assurance.

5.10.3 Procedures for the control of activities which affect quality shall include documented inspection requirements. The Manager, Quality Assurance is responsible for approving the QA aspects of inspection procedures as required to implement the Nuclear Quality Assurance Program-Design and Construction.

5.10.4 These procedures are provided to define the necessary inspections which are required to assure the following:

5.10.4.1 An appropriate inspector evaluation/qualification program is established.

5.10.4.2 Inspection personnel are independent of the individual or group performing the activity being inspected.

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5.10.4.3 Inspection procedures, instructions and/or check lists are provided and contain as a minimum the following:

5.10.4.3.1 Identification of quality characteristics to be inspected.

5.10.4.3.2 Identification of those individuals or organizations responsible for performing the inspection operation.

5.10.4.3.3 Acceptance or rejection criteria.

5.10.4.3.4 Description of the method of inspection.

5.10.4.3.5 Evidence of satisfactory completion and certification of inspection and materials.

5.10.4.3.6 Record of the results of the inspection.

5.10.4.3.7 A method of follow-up and conclusion to all final analyses.

5.10.4.4 The required quality shall be maintained even when inspection is not possible or disadvantageous. This is achieved through indirect control by monitoring of processing methods, equipment, and personnel. Both inspection and process monitoring is provided when control is inadequate without both.

5.10.4.5 Prior to performing an inspection operation, the following requirements are met:

5.10.4.5.1 Inspection procedures or instructions are available to include applicable drawings and specifications.

5.10.4.5.2 Inspection equipment is within the calibration standards.

5.10.4.5.3 Certifications of qualified personnel performing inspection are current.

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5.10.4.5.4 All personnel required or requested to witness the activity have been notified and are present unless formal waivers have been made.

5.10.4.5.5 All safety precautions related to the health and well being of the participants and observers are evaluated prior to the start of the activity such as health, shielding, hard hats, and safety glasses.

APPENDIX C

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NUCLEAR
QUALITY ASSURANCE
PROCEDURES

QAP Number: 2100
Page: 1
Revision: 0
Date: February 10, 1975
Approved:
Approved:

Subject:
INSPECTION

1.0 PURPOSE

The purpose of this procedure is to establish measures to control the inspections required during the design, procurement, construction, and operations of Nuclear Power Station, including preoperational testing, initial start-up, and inservice inspection. It also establishes the methods of control of inspection records and reports.

2.0 SCOPE

This QAP is applicable to all inspections of Q-List items and nuclear safety related activities performed by its agents, and suppliers/ contractors.

3.0 RESPONSIBILITY

The Quality Assurance Manager is responsible for the development, control, and implementation of this QAP.

4.0 REFERENCES

4.1 ANSI N18.7, Administrative Controls for Nuclear Power Plants.

4.2 ANSI N45.2, QA Program Requirements for Nuclear Power Plants.

4.3 ANSI N45.2.4, Installation, Inspection and Testing Requirements for Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations.

4.4 ANSI N45.2.5, Supplementary QA Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants.

4.5 ANSI N45.2.6, Qualifications of Inspection Examination, and Testing Personnel for the Construction Phase of Nuclear Power Plants.

REVISIONS

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4.6 ANSI N45.2.8, Supplementary QA Requirements for Installation, Inspection, and Testing of Mechanical Equipment and Systems for the Construction Phase of Nuclear Power Plants.

4.7 ANSI N45.2.9, Requirements for Collection, Storage, and Maintenance of Quality Assurance Records for Nuclear Power Plants.

4.8 ASME Boiler and Pressure Vessel, Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components.

4.9 Nuclear Quality Assurance Manual.

4.10 QAP 1040, Training and Qualification of Non-QA Personnel.

4.11 QAP 2030, Design Control.

4.12 QAP 2040, Procurement Document Control.

4.13 QAP 2050, Instructions, Procedures and Drawings.

4.14 QAP 2140, Inspection Test and Operating Status.

4.15 QAP 2170, Quality Assurance Records.

4.16 QAP 2180, Audits.

5.0 FORMS

Not Applicable.

6.0 GENERAL

The Nuclear Quality Assurance Program requires a system of inspections during design, fabrication, assembly, construction, preoperational testing, start-up, and operations of Nuclear Power Station to verify the conformance of Q-List items and nuclear safety related activities to established quality requirements, and a record system to document the completion of inspection activities. Inspection activities are controlled in accordance with this QAP and the following related QAP's:

6.1 QAP 2101, Inspection Check Lists.

6.2 QAP 2102, Inspection Methods.

7.0 PROCEDURE

7.1 Inspection of Q-List items and nuclear safety related activities are conducted in accordance with approved written inspection procedures which define the inspection parameters to verify conformance with quality and design criteria. The following measures shall be provided for by inspection procedures:

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7.1.1 Description of the inspection to be performed and identification of the equipment or activity inspected.

7.1.2 Required inspection check lists.

7.1.3 Required test and measuring equipment including calibration requirements.

7.1.4 Personnel training and qualification requirements.

7.1.5 Assurance that personnel performing the inspection are independent of the activity being inspected.

7.1.6 Assurance that all pertinent instructions, procedures, drawings, and related documents are available prior to the inspection.

7.1.7 Inspection methods or techniques.

7.1.8 Appropriate accept/reject criteria.

7.1.9 Requirements for the documentation and resolution of deficiencies and nonconformances.

7.1.10 Requirements for tagging, marking, or stamping to indicate current inspection status.

7.1.11 Requirements for documenting and disposition of inspection results.

7.1.12 Identification of mandatory hold and witness points, including resolution of deficiencies and nonconformances before continuation of the inspection or processing.

7.1.13 Inservice inspections are identified by inspection frequency and are to be performed during the station lifetime.

7.2 The Project Engineer is responsible to assure that inspection requirements for the design, procurement, and construction phase are identified and incorporated into appropriate design, procurement and construction documentation in accordance with QAP 2030, Design Control, QAP 2040, Procurement Document Control and QAP 2170, Quality Assurance Records. He is responsible to assure that agents and suppliers/contractors properly document inspection results in accordance with design and procurement requirements.

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7.3 The Station Superintendent is responsible to assure that inspection requirements for preoperational testing, start-up and the operations phase, including inservice inspections, are implemented by written inspection procedures which are prepared, approved, and controlled in accordance with QAP 2050, Instructions, Procedures and Drawings. He is responsible to assure that inspection reports and records are properly prepared and dispositioned in accordance with QAP 2170, Quality Assurance Records.

7.4 The following is a suggested list of items to be considered in the planning of inspections and the documenting of results:

7.4.1 Personnel performing inspection activities are trained and qualified in accordance with QAP 1040, Training and Qualification of Non-QA Personnel.

7.4.2 Inspections are scheduled to assure completion and evaluation on a timely basis.

7.4.3 Documented inspection results must be available onsite and accompany each Q-List item or nuclear safety related activity prior to final acceptance of the item or system.

7.4.4 Inspection results are a part of the permanent record of the inspected structure, system or component.

7.4.5 Following an inspection, systems are returned to a normal configuration and tagged, marked or stamped to indicate status, in accordance with QAP 2140, Inspection, Test and Operating Status.

7.5 Distribution of inspection records and reports shall be made to appropriate persons and organizations and should include the following:

7.5.1 Description of the inspection.

7.5.2 Specific identification of the item or activity inspected.

7.5.3 Date of inspection.

7.5.4 Inspection results.

7.5.5 Acceptability of results and/or corrective action resulting from nonconformance.

7.5.6 Identification and signature of inspectors and data recorders, as appropriate.

7.5.7 Identification and signature of final approving authority of of inspection results.

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7.6 The Quality Assurance Manager is responsible to assure compliance with this QAP through periodic audits conducted in accordance with QAP 2180, Audits.

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